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GEOLOGICAL FEATURES
OF THE
TRANSVAAL

CHARLES J. ALFORD, F.G.S.

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IN MEMORIAM
Arthur Eaton

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GEOLOGICAL FEATURES

OF

THE TRANSVAAL.

MADE IN GREAT BRITAIN.

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GEOLOGICAL FEATURES

OF

THE TRANSVAAL,

SOUTH AFRICA.

BY

CHARLES J. ALFORD, F.G.S.

WITH MAPS AND ILLUSTRATIONS.

LONDON: EDWARD STANFORD,
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In Memoriam
Arthur Eaton

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PREFACE.

UNTIL the last few years the Transvaal was a land known to few but as a hunting ground, and as the habitation of a few discontented Boers who had migrated from the British colonies and found on these wide grassy plains a residence more suitable to their extraordinary love of isolation. Rumours of rich gold-fields north of the Vaal river reached the outer world from time to time as travellers and hunters went and came, until first the Lydenburg district, then that of Barberton, and lastly, the Witwatersrand attracted adventurers, resulting latterly in one of the greatest mining "booms" which the world has ever witnessed.

Several valuable papers have been written on the geology of the better known parts of the country by E. J. Dunn, W. H. Penning, and others, and the northern districts have been visited and described by those enterprising travellers Bain and Button; but hitherto, no general description of the geology of the Transvaal has been put before the public in a popular

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form. The author trusts, therefore, that the following sketch of the outlines of the subject as they have presented themselves to his view during three years of almost continuous travelling in the districts to the north and east of the Vaal river, will not be uninteresting to the general reader, whilst to the geologist it may offer some assistance and possibly form a basis for future more perfect work. The friendly critic will recognise the great difficulty to be met with in undertaking the most cursory delineation of the geology of a country of which no topographical survey has been made, and pardon the many errors which must necessarily attend this first attempt at a collective description of the geology of the Transvaal. The aim of this little work is rather to stimulate inquiry than to attempt much on so great a subject, and notices of errors or shortcomings will be most gratefully received by the author.

CHARLES J. ALFORD.

JOHANNESBURG, TRANSVAAL,
SOUTH AFRICA,
October 1890.

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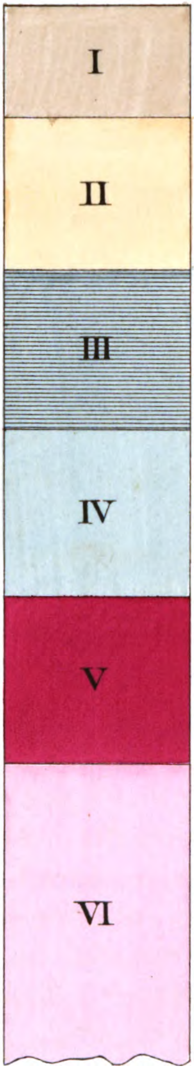
Plate I. *to face page 1.*

Explanation of the

GEOLOGICAL COLOURS



I	Alluvial deposits, sand, peat, recent clays, and drift.
II	Silicious sands and clays with local beds of coal.
III	Sandstones passing into sandstone quartzites, with interbedded conglomerates.
IV	Clay mudstones, schists, and shales, with beds of compact quartzite.
V	Trappean rocks, generally intrusive and of the greenstone class.
VI	Granite rocks— Granite, syenite, gneiss, pegmatite, quartz porphyry, felsite rock, and others.

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GEOLOGICAL FEATURES
OF
THE TRANSVAAL, SOUTH AFRICA.

CLASSIFICATION OF ROCKS.

THE first difficulty which confronts the geologist commencing work in a new country is the classification of the stratified rocks, and this is undoubtedly a matter of no small importance, as names once given are not readily suppressed, and an ill-advised nomenclature once adopted becomes a constant source of difficulty and annoyance to subsequent workers. The adoption of the names of European geological formations should be carefully avoided until the correlation is proved by fossiliferous or other evidence beyond a doubt, and the conclusion accepted by competent authority. Some of the stratified beds of the Cape Colony have been so proved, and the classification consequently definitely accepted; but in the Transvaal, where the sedimentary rocks are mostly of a highly quartzose character and very poor in, if not entirely destitute of fossils, no evidence is as yet available to connect them with any of the recognised formations. Any attempt to correlate rocks of this class on lithological evidence alone is but to court disaster and error. The application of local names to local strata is also often attended with serious difficulty, as beds of an identical character by this means often receive different names in different localities. For instance, a certain clay shale has received the several names of *Lydenburg shales*, *Maritzburg shales*, and *Namaqualand schists*, in those several districts, though the beds exhibit the same characteristics in all. Until the geology of the country has been the subject of a far greater amount of study than has been hitherto accorded to it, much trouble will be saved by abstaining from giving any names whatever to the strata other than those which denote only their petrological character.

A broad division of the rocks of the Transvaal, as hitherto observed, results as follows. (See General Map.)

I. Alluvial Deposits.—Under this head are included a very varied assortment of recent rocks which have accumulated on the surface during a very long period of exposure to subaerial denudation, and which at times attain a great thickness. These beds consist chiefly of *peat*, *sand*, *recent clays*, and masses of *drift*, all of them being invariably of the highly quartzose nature of the rocks from which they have been derived, and also carrying much iron in the form of *pyrites*, *magnetite*, *red oxide*, and *limonite* or *bog iron ore*, which latter mineral forms in places considerable beds. The drift beds are composed usually of boulders and pebbles derived from adjacent rock masses, and do not appear to have travelled any great distances. In several places deposits of a fairly pure crystalline *carbonate of lime* are met with, those in the vicinity of the six mile spruit between Pretoria and Johannesburg being some of the most remarkable; these appear to result from the disintegration of a hard blue quartzite plentifully veined with lime which occurs in the neighbourhood, and which we here place as belonging to Class IV.

II. Coal Formation.—These rocks form the uppermost of the geological series of the districts under consideration, with the exception of the above described surface deposits, which require a great amount of study before they can be adequately described in detail. They consist of beds of a highly silicious sandstone intercalated with clays, shales, and local beds of coal. The coal beds are lenticular in form, and though very numerous do not individually cover any largely extended areas. The sandstones are the most conspicuous beds of the series, and are recognisable for great distances in many parts of the country. In places the whole of these beds have been greatly altered in character by contact with the intrusive igneous rocks of Class V., but they are never moved in any considerable degree from their horizontal position. Beyond a few coal fossils which will be hereafter noticed, nothing of the nature of the remains of living organisms has hitherto been met with in these rocks. In many cases these strata rest unconformably on the underlying beds, but in other cases it is a doubtful point. The question of their general unconformability or otherwise has yet to be definitely determined.

III. Stratified Sandstones and Quartzites.—Underlying the coal formation and exposed at the surface over very considerable areas, we find a series of sandstones and sandstone quartzites—that is, quartzites which still retain traces of the granular structure of the sands from which they were formed—and interbedded with them masses of quartzose conglomerate, the latter becoming in some places auriferous, sometimes, as in the case of the *reefs* of the Witwatersrand, to a very valuable degree. These beds vary very greatly in thickness, and though usually retaining very nearly their normal horizontal position, are occasionally found, notably in the case of the Witwatersrand, tilted up to a very high angle of dip. They are very noticeable along the Drakensberg Mountains, where they cap the hills and form a very distinctive feature of the landscape. In some instances a marked unconformability exists between these beds and the underlying strata, as in the case of the Makongwa range of mountains to the south-east of Barberton, but in general they are conformable to each other. Where the quartzite beds have suffered from long continued erosion they assume in many cases the most fantastic shapes, as seen at Barrett's Berlin, the Kantoor, and in other places.

IV. Schistose Rocks.—Below the above described quartzite and conglomerate beds come in a series of clay shales, mudstones, flagstones, and compact quartzites—that is, quartzites which do not show any granular structure, all of which beds are highly silicious in their character, and appear to be closely related to each other; in some cases they pass from one to the other by almost insensible gradations. The shales on the surface pass downwards into schists, flagstones, and mudstones as depth is attained. The quartzites of this series are in some cases auriferous, as in the case of the Sheba mine, near Barberton, and quartz intercalated with the schists is also often found to carry gold in considerable quantity. Deposits of this nature are being worked in many parts of the country. This series appears to form the lowest in the geological scale of the country, its lower beds resting directly upon the granitic rocks, and the beds are generally much altered and dislocated by intrusions of trappean rocks; thus they naturally assume every sort of position from the horizontal to the perpendicular. The metamorphism of these beds where in contact with, or adjacent to, the irruptive rocks, results in several somewhat complicated products, amongst others the calcareous quartzite before mentioned, which in some places passes into dolomite, and on exposure to atmospheric influence yields up its lime and becomes on the surface altered into a species of chert. This calcareous quartzite is locally known as *elephant rock* from the resemblance which its weathered surface bears to the hide of that animal. In other places, as on the hill near the junction of the Olifants and Blyde rivers, it has resulted in very calcareous beds of granular quartzite, bearing in structure a marked resemblance to dolomite, in some of which the silicious and calcareous matter has assumed a peculiar banded arrangement.

V. TRAPPEAN ROCKS.—It is not proposed at present to attempt any exhaustive or detailed description of these igneous rocks which have played so important a part both in the geological and petrological structure of the country; indeed, without a critical examination under the microscope, it would be useless to do so. They are basic igneous rocks of the greenstone class, or analogous thereto, in which felspar and hornblende, pyroxene, or magnetite are the essential constituent minerals. In texture they vary greatly, as in some cases the crystals are very large and distinct, whilst in others they are hardly distinguishable without the aid of a microscope. There is, no doubt, very considerable variety in their composition, but until a more exhaustive study has been accorded them it will be better, in order to avoid any grave error, to include all these rocks under the comprehensive term which we have here applied to them. These rocks occur repeatedly in all parts of the country where they have been exposed by the removal of the superincumbent strata by denudation. Their age appears to be contemporaneous with, if not posterior to, the sandstones and clays of the coal formation, as these, together with the underlying strata, are upheaved and altered, both in position and structure, by them. They form dykes and intrusive sheets in all the strata, and are very conspicuous where penetrating the granite of the low country lying towards the coast on the eastern side of the Drakensberg Mountains. The results of their decomposition are the usual red greasy clays.

VI. GRANITIC ROCKS.—Under this head we include, for the present, a large and varied assortment of rocks, rich in silica, and whose essential constituent minerals are felspar and quartz together, generally, with mica or hornblende. They are in this case invariably older than those of the trappean group, by which they are constantly penetrated. At the surface these rocks are much disintegrated to a great depth, bearing evidence to a long extended period of subaerial exposure. *Granite*, *syenite*, *gneiss*, *pegmatite*, and other rocks of a like nature are of very frequent occurrence—indeed, they probably form the basement of the whole of Southern Africa. The granite is very varied in texture and colour, at times being fine-grained and compact, with the minerals of its composition fairly equal in proportion, at others it becomes porphyritic in structure, with large and well-defined crystals of felspar. In the former case it is usually grey and in the latter pink. To the movements of these ancient rocks are due, to some extent, the geotectonic features of the country, but to a far greater extent are they the result of the subsequent intrusions of the trappean rocks before noted.

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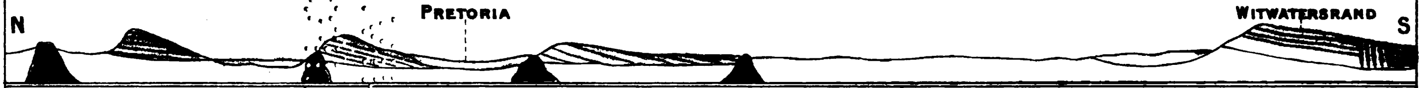
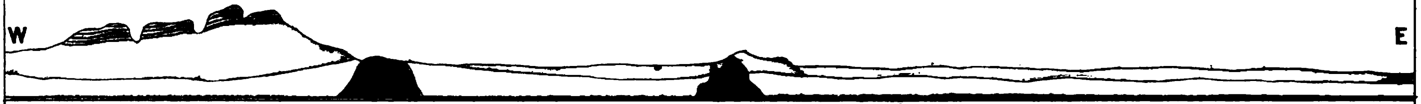
Plate II. *to face page 9.*

GEOLOGICAL SECTIONS.

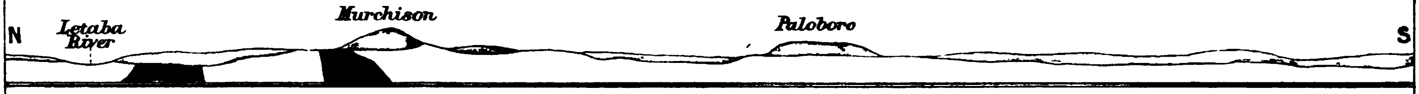
Section through PRETORIA and JOHANNESBURG.



Section through the DRAKENSBURG into the low country.



Section across the MURCHISON HILLS.



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STRUCTURAL GEOLOGY.

The history of the dynamical geology of the Transvaal, or the movements by which the various rocks of the country gradually reached the conditions and positions in which we now find them, is by no means an easy one to trace. We must recognise as the predominant agency in the production and arrangement of the rocks of this country, that of very long extended periods of action under the agencies of heated and effluent water, rather than anything catastrophic or violent. As far as the results of present observations go, the sequence of geological action appears to have been somewhat as follows:—

1. Solidification of the granitic rocks, and the deposition upon them of the lower series of argillaceous and quartzose strata.

2. The deposition, by varying currents of effluent water, of beds of sand and quartz pebbles upon the rocks of the former series; the constituents of these beds being probably brought from a great distance. The transporting water also carried a comparatively small quantity of argilla-

ceous matter, which it deposited as mud in sheltered places, and, being probably at a high temperature, it would also carry silica in solution.

3. A very general and widely extended intrusion of the trappean rocks, probably under water and not reaching the surface, effecting a general dislocation and disturbance of the partially hardened strata, and producing a considerable metamorphism in their lithological structure over a very largely extended area.

4. A bringing down of very great quantities of pure quartzose sand, with some argillaceous and much drifted vegetable matter, which, on being deposited in sheltered places on the uneven surface of the lower series of altered and dislocated rocks, then in the process of cooling, produced the present coal deposits. This period of deposition was probably attended with a still further inruption, or at least a movement, of the trappean rocks.

5. A gradual upheaval of the whole system, accompanied by considerable denudation, resulting in the exposure of parts of the lower series, and also of the intrusive igneous rocks, by the removal of the overlying strata. In the eastern parts of the country this upheaval apparently resulted in a very pronounced folding together of the lower strata, then probably in a pasty condition, and the entire removal of much of it, with the whole of the newer beds, from the surface of the granitic rocks below.

6. A very long extended period of subaerial denudation lasting to the present time, during which all the surface and alluvial deposits were laid down, and the land surface gradually assumed its present contour.

This long sequence of geological action leaves us with the lower series of sand-beds mostly converted into quartzites (in some of which strata the granular structure of sandstone is more or less preserved), the clays into shales, schists, and flagstones, and the beds of pebbles into conglomerates. In places where the strata are observable in close proximity to the trappean rocks, the former are found to be dislocated and traversed in all directions by surface fissures, in many cases highly mineralised. Most of these fissures are found conformable to the stratification of the beds in which they are enclosed, and are evidently terminable at no great depth beneath the surface, whilst a few, which will be noticed in their proper places, form mineral deposits of workable extent. Hitherto, very few indications of any true fissure-veins, such as would cut through all the rocks alike and be practically interminable in depth, have been met with; and those few appear to be confined to the granitic rocks and their immediate vicinity. No traces of any recent volcanic action have hitherto been noted in the country, with the exception of a few warm springs, which bring up nearly pure water, and deposit little or no precipitate; their origin will become a most interesting subject for future study. In no case have any recent lavas or volcanic products of that class been observed in any part of the country as yet explored.

The remains of animal or vegetable life as fossils are exceedingly rare. In the coal-beds and their accompanying sandstones and shales, a few indistinct impressions and casts of coal plants are to be found; but shells or other evidences of animal life appear to be entirely absent, a fact which is not at all surprising considering the highly quartzose and ferruginous nature of the majority of the stratified rocks of the country; but it is to be regretted, as, without such evidences, the very interesting problem of the correlation of these beds with any of the recognised geological formations becomes exceedingly difficult, if not impossible. We may, however, assume that they are, with the possible exception of the coal formation, of very ancient geological date.

The general strike of the outcrops of the upturned edges of the disturbed strata is about east and west, and the general dip to the southward; the rivers, such as there are, run east or west, and the ranges of hills lie in the same direction; also the surface deposits usually lie in greater volume to the southward than to the northward of the rock masses from which they derived their origin. Consequently, it appears that the earth movements which have upturned and broken the stratified rocks, as also the denuding forces which have planed down their edges and redeposited the debris in the form of surface deposits, have been exercised in a direction from north to south or thereabouts.

The general contour and scenery of the Transvaal strikingly illustrate its geological structure. The sandstones of the coal formation form flat-topped or but slightly rounded hills, generally not of any great height individually, though that formation occupies the highest parts of the country.

The stratified quartzites with their attendant conglomerate beds form bold escarpments with intervening deep ravines. The schistose rocks, underlying the harder quartzite beds, present themselves in the lower slopes and foothills of the mountains, in flat beds on the surface of the granitic rocks, and where thrown up into a vertical position and supported by the more durable beds of compact quartzite, in steep-sided but rounded mountains. The granites can be readily recognised by the immense rounded blocks piled one upon the other, or showing their curved surfaces from beneath the surface sands and soils. The trappean inruptive rocks form sharp and very distinct ridges, and in places cover the surface of the ground with blocks and boulders, showing a very characteristic conchoidal or egg-shaped weathering. The low-lying swamps, or vleis, are mostly of a sandy loam passing into peat where vegetable matter has accumulated. These features are generally so well marked, that a glance over the country in almost any part will give at once to the experienced eye a very fair idea of its geological structure.

The question as to the origin of this immense mass of quartzose and argillaceous matter, now forming the stratified rocks of the country, is certainly a most interesting one, but one with which it would be out of place to deal in the present work. That they originated from the erosion and disintegration of vast masses of some granitic rocks can be readily understood, but whereabouts was the position of these rocks when *in situ* is not so easy to determine; they may have formed the mountain ranges of that mystic continent which some have considered once occupied the position of the present North Atlantic Ocean. Certainly the land-surface from which these materials were derived has long ages ago been obliterated from the surface of the earth.

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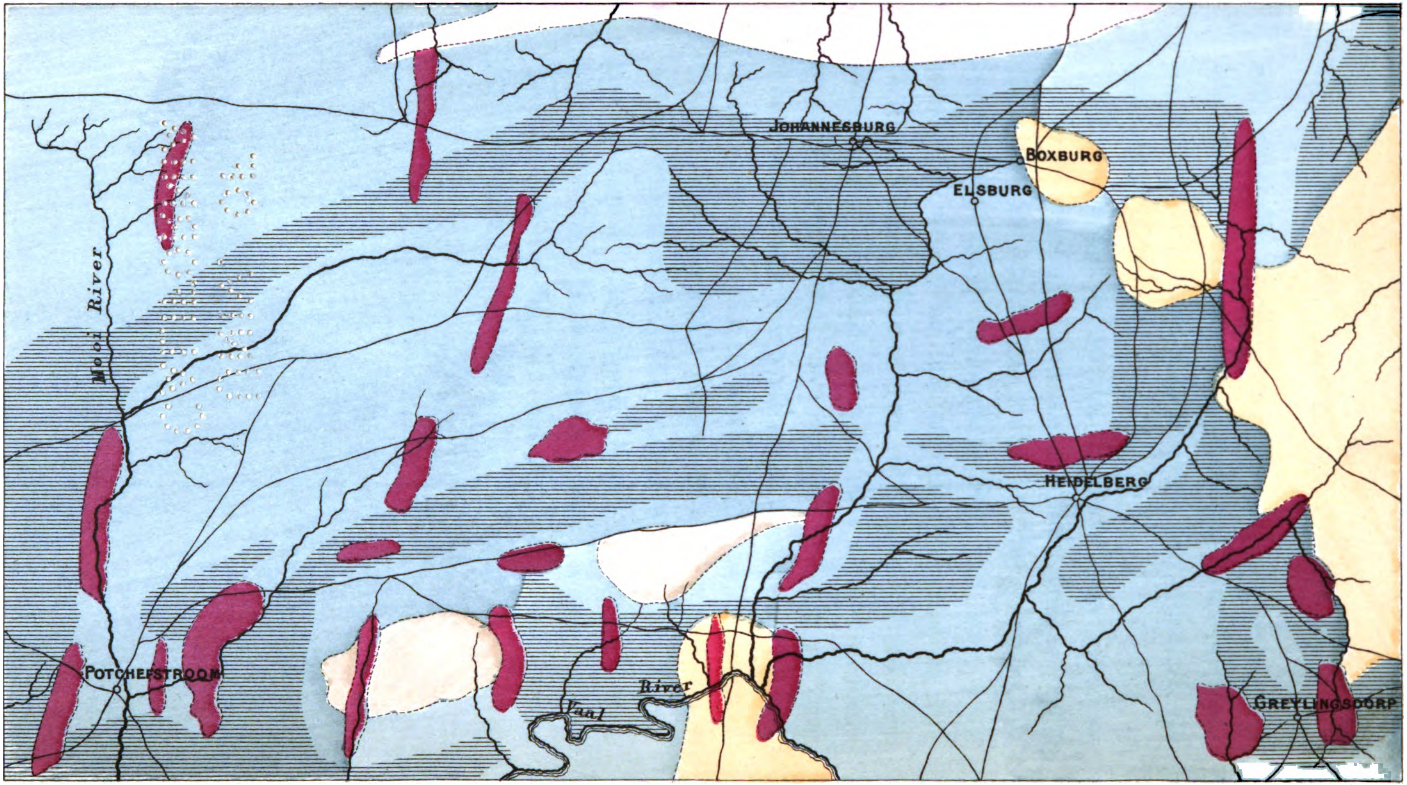
Plate III. Geological sketch map of the Witwatersrand district. *to face page 15.*



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THE WITWATERSRAND.

THE Witwatersrand, or White Waters Ridge, as the name would be rendered in English, is a range of hills of no great height above the surrounding country, situated about thirty-five miles south of Pretoria, the capital town of the Transvaal, and is the site of Johannesburg, which town lies on their southern slope, and is the present centre of the mining and commercial industries of the country. For our present purpose we will take the Witwatersrand district to embrace the neighbourhoods of Johannesburg, Pretoria, Heidelberg, Potchefstroom, and Klerksdorp. This district is situated on the high tableland which occupies the central portion of the Transvaal, at an elevation of some six thousand feet above the level of the sea. The highest point of this tableland is probably somewhat further to the east in the neighbourhood of Lake Chrissie, where it is said to attain an altitude of about seven thousand feet. The country is flat and undulating, broken only by a few rocky ridges of no considerable height, formed by the breaking up of the strata by the intrusive rocks. In the wet season it is covered with rank grass, which, succumbing to the cold dry winds and frosts of winter, disappears and leaves a bare and desert prospect until the rains return. Excepting only where they have been planted in the neighbourhood of some of the older Boer towns, the country is entirely destitute of trees of any size; though tree-planting is lately becoming an industry, and a few years will show a very different scene. At present a few clumps of scrubby bush, growing in the more sheltered positions, alone represent the arborescence of the Highvelt, as these elevated districts have been named by the Boers. The climate is salubrious at all times of the year. During the wet season, from October to March, there is usually a very considerable rainfall, but during the rest of the year the climate is very dry, and bitter cold winds sweep across the exposed surface of the country, from which the Boer farmers escape with their flocks of cattle and sheep into the more low-lying and consequently warmer districts. In all seasons of the year the Witwatersrand district is eminently suited for the habitation of Europeans, and for their employment at manual work of any kind; and there is no reason whatever, except the presence of the native Kafirs, why they should not work here as well as in Europe, America, or Australia.

As in all other parts of South Africa under Boer government, means of communication are at present sadly deficient, the primitive ox-wagon, with a few lines of post-carts and passenger coaches, doing all the transport of the country; railways, or even adequately made roads or bridges, there are none. Fortunately there are no rivers of any considerable size, and the streams, though impassable when swollen by heavy rains, soon run down and become again fordable. The distance from Johannesburg to the Natal frontier at Coldstream, to which place the railway from Durban will shortly be completed, is about 160 miles; to Bloemfontein, the capital town of the Orange Free State, and the terminus of the railway from Port Elizabeth, about 250 miles; to Fourteen Streams on the Cape Town line, about 220 miles; and to Vryburg, on the Bechuanaland railway, about the same distance. This latter line will shortly be completed to Mafeking, which is only about 160 miles in a direct line from Pretoria. Delagoa Bay, on the east coast, is about 250 miles from Pretoria, and a railway from there has been long talked about, but the engineering difficulties in bringing it up the Drakensberg Mountains from the low country are such that it will probably be a long time in construction; whilst none of the other routes above mentioned offer any considerable difficulties to railway engineering. Communication by railway with the coast, and the consequent cheapening of everything, is a vital necessity to the profitable working of mines in this district.

In noticing the geological structure of the part of the country now under consideration, it is with the beds of quartzite and conglomerate which were deposited during period No. 2 that we have principally to deal, and the greatest interest necessarily attaches to the conglomerates which form the renowned auriferous *reefs* of the Witwatersrand gold-fields. Deposited, as we have already noticed, by varying currents of effluent water, they were originally laid down in zones or beds of pebbles, alternating with beds of sand and clayey matter, and would thus be naturally more or less lenticular in structure and very variable in extent. The great upheaval and dislocation of these strata caused by repeated inruption of the trappean rocks accompanied by movements of the granitic base, placed them probably altogether or very nearly in their present position; and the subsequent removal of the overlying strata, together with the very general cutting away of the surface during long subsequent periods, has left the edges of these upturned beds in many cases exposed at the surface, forming the outcrops of the present *reefs*. As the placing of the surface of the ground in its present horizon is purely incidental, and the beds of conglomerate are many and widely distributed in the series of sandstone quartzites, consequently the exposure of the edges of those beds which form the present reefs is accidental, and it may be safely assumed that many more beds exist than are now found outcropping at the surface.

The renowned *main reef* of Johannesburg, and its attendant *leaders* and *reefs*, are the upturned edges of certain of these conglomerate beds which can be followed by their outcrops on the surface east and west of the town for many miles. The whole form a series varying from 10 to 200 feet in thickness, composed of several beds of conglomerate varying in number, separated from each other by a sandstone quartzite, white to red in colour in the upper and oxidised zones and white to blue in depth, carrying in some places traces of granitic clay, mica, and talc, but usually free from the presence of any accessory minerals. The distance of these beds from each other, their number, thickness, dip from the surface, and gold-bearing value, vary very greatly in their lateral extent.

The thickness of what is known as the *south reef*, which, as its name implies, lies southernmost in the series, varies from about six inches up to three feet, and in some places it is very rich in gold, assaying occasionally as high as ten or twelve ounces of gold per ton of rock. To the north of this occurs in some parts of the series a bed, which has been named the *middle reef*, which appears to vary from a few inches up to over two feet in thickness, and which is also occasionally very rich in gold. Still further northward and at a distance varying from 20 to 150 feet from the south reef, occurs a persistent little bed known as the *main reef leader*, from which hitherto the greatest general results on these fields have been obtained. It is usually found from six inches to two feet in thickness, and carrying gold in places up to six or eight ounces per ton of rock. At a short distance further to the northward—sometimes only a few inches—lies a very large deposit, the *main reef*, varying in thickness from about four up to as much as forty feet, and carrying from a trace of gold up to perhaps an ounce in places. This great mass of conglomerate has been hitherto but little worked upon, its richer though smaller companions offering greater attractions to the miner; it will, however, have its day in the future. North of the main reef, at a distance of from twenty to one hundred feet, there lies an almost unexplored and little noticed deposit known as the *north reef*, which, so far as it has been examined, appears to vary from one to five feet in thickness, and to carry gold from a trace up to nearly an ounce per ton of rock. As with the main reef so with this, its day of importance has yet to dawn when the richer portions of the series have been worked out.

It must not be assumed that this series of upturned conglomerate beds is by any means absolutely continuous.

It appears probable that even the well-known reefs lying south of the main reef are themselves made up of deposits of somewhat different horizons. In some parts the individuality of each is much obscured, pebbles of the same nature being disseminated freely through the quartzite partings, which are then often found to carry gold. In addition to this normal want of continuity in the beds themselves, we find along the entire series that it is repeatedly faulted and thrown out of line, sometimes to a very great extent. The most regular part of the gold-bearing deposits yet known in this district is the line of outcrops which extends for a distance of about twelve miles to the east, and the same distance to the west of Johannesburg.

Along this line the beds are faulted repeatedly, but never to a greater distance than about one hundred feet, and their line of east and west strike is very well preserved. The *vleis*, or swampy places, appear usually to mark broken ground, and probably the near approach of the igneous rocks, whilst on the higher ground less disturbance is apparent. The dip of the beds varies very greatly all along the line, in some places they are nearly perpendicular, and in others the dip does not exceed ten or twelve degrees. It is invariably to the south. At a short distance north and south of the reef outcrops the strata of altered sandstone appear never to attain a greater dip than about forty-five degrees south, thus producing, where the reef beds are perpendicular, two lines of unconformability, one north and the other south of the series of reefs. It is probable that these strata contain other beds of conglomerate of a like nature to those now worked, or other portions of the same beds broken off in the general upheaval of the strata, which do not appear at the surface.

The question of the continuity of these beds in depth is undoubtedly a serious one for the gold-miner, and on this two theories suggest themselves at present. One is that in depth they will gradually decrease their angle of dip, and turning to the south, continue with their enclosing strata until their normal limits are reached, in which case the lines of unconformability above alluded to would be but a surface disturbance and would disappear in depth.

Another possible case is that the break up of the strata has been more pronounced than the former would assume it to have been, and that in depth the line of fracture of the beds will be reached, in which case the continuance of the deposit must be looked for amongst the more horizontal portions of the strata to the south of the present line. There is also the remote contingency that the original limits of the conglomerate beds are in the present upturned part of the series, and may be reached in depth, but this would involve the assumption of an area of deposition so totally out of proportion in length to breadth, or, on the other hand, a denudation of the surface so vast, as to be absolutely incredible. Probably both of the first two hypotheses will be found borne out in different parts of the district as the dislocation of the strata has been more or less acute.

Passing from the line of the main reef proper of Johannesburg to the eastward, the series of rocks above described becomes so broken up that the several outcrops can no longer be followed with any degree of accuracy. About the village of Boksburg occurs the same series of sandstone quartzites with conglomerates continuous from Johannesburg, but the strata are broken up and thrown about in all directions, strike and dip altering completely every few hundred yards. There is, however, a distinct trending away of the outcrops towards the south, due, possibly, to the normal position of the edges of the basin-like deposits, but more probably to the direction of the axis of disturbance. The substructure of this part of the district is much obscured by surface deposits of detrital rocks, derived mostly from the disintegration of the reef series, and also by being overlaid by outliers of the upper series of rocks of the coal formation, by which, further to the eastward, the quartzite and conglomerate strata are completely covered, appearing only in small patches where the upper beds have been cut through by denuding forces. Under much the same conditions the same series of conglomerates and altered sandstones can be traced through and to the eastward of the town of Heidelberg for nearly sixty miles south to the Vaal river, in the neighbourhood of which they disappear under the sands and clays of the coal formation. In places they have been removed by denudation, and the lower clay beds, or the intrusive trap rocks, appear at the surface; in others they are covered with masses of detrital matter, but the formation is distinctly recognisable over the whole area.

To the westward of Johannesburg, also, after leaving the line of the main reef proper, the continuity of individual strata is lost or obscured, but the characteristics of the series can be followed past Krugersdorp, south-west to Potchefstroom and Klerksdorp, a distance of about one hundred miles. The conglomerates appear to be very generally auriferous all along the line in a greater or less degree. To the south and south-east of Potchefstroom and Klerksdorp, along the banks of the Vaal river, the same series of rocks is also recognisable, upheaved into a perpendicular position in places, and the conglomerate beds are said to yield fair auriferous results.

The country south of Johannesburg to the Vaal river is much broken up by repeated intrusions of trap rocks and covered by deep deposits of drift and detritus, the granite appearing occasionally in the beds of the streams where the overlying strata have been cut through and removed.

In the neighbourhood of Wonderfontein and in other places, the erosion of the exposed surface of the altered sandstone has produced very peculiarly weathered rock-masses, and the underground watercourses have resulted in the formation of many a series of extensive caves, the tortuous windings of which can be followed for a long distance, and which form the underground course of the Mooi river. In the calcareous quartzite before alluded to, the river has in course of time worn for itself a subterranean course by dissolving out, in the first instance, the little veins of calcite, and then, when increasing volume gave it greater strength, the quartzite also, the lime being again deposited as stalactitic formations in the caves. The upper parts of these caves are always accessible, but the lower can only be reached in dry weather when little water is passing down. Some parts of these quartzite beds are sufficiently calcareous to produce on calcination a valuable lime.

It must not be assumed that the conglomerate beds above described are by any means uniformly gold-bearing, and so far the data on which to base any theory regarding the auriferous value of the deposits in relation to their structural or lithological characters is of the most meagre description. The observed characteristics of the gold-bearing deposits, hitherto recorded, may be classed as follows:—

(*a*) Conglomerates formed of rounded pebbles of white to grey, vitreous or subcrystalline, quartz usually not exceeding the size of a hen's egg, and set in a hard matrix of highly ferruginous quartzose matter. The beds of this class sometimes carry traces of mica and talc, but are usually purely quartzose and free from accessory minerals.

(*b*) Conglomerates in which pebbles of quartz of varying colour and texture are associated with pebbles and brecciated fragments of sandstone, quartzite, and other local rocks. In these deposits the size of the pebbles and rock fragments is very varied, many attaining a large size, also accessory minerals become more abundant.

(*c*) Surface deposits of earthy, ferruginous, and vegetable matter, with rock fragments of varied shape, size, and description, showing in many cases evidences of the decomposition of the trappean rocks.

(*d*) Surface fissures, usually conformable to the stratification of the beds in which they occur, filled with quartz, mica, talc, and silicious clay, generally highly ferruginous, the gold usually occurring in the ferruginous matter rather than in the quartz. Class *a* comprises the beds forming the main reef of Johannesburg, and deposits of the same nature are found all along the lines on which the reef series of rocks has been traced. In the more disturbed regions the other classes of deposits become more frequent, as would naturally be expected; but the former class has hitherto been found most reliable both in the gold-bearing value and continuity of the beds.

The manner of the occurrence of the gold in these deposits is a subject of great interest, and one which deserves a careful study. So far as has yet been noticed, the gold is almost invariably in a more or less crystalline form; the cube and its derived forms being generally detectable. The gold set free from pyrites when that mineral is destroyed by treatment with acid, appears usually in the form of minute plates and scales, also in form referable to the cube. It is usually found that gold occurs very much more abundantly in the matrix than in the pebbles of the conglomerate, and more so in that part of the matrix immediately adjacent to each pebble. On removing a pebble from its bed in the conglomerate, the resulting cavity, as also the surface of the pebble, are often found covered with minute crystals of native gold. It is also to be noted that the pebbles themselves in very few cases are auriferous, in many cases showing no trace of gold on assay; they usually show signs of having undergone severe crushing, being exceedingly brittle and full of minute fissures, which render parts of them opalescent when exposed to sunlight. It appears certain that the gold was not transported to its present position, in the form of native gold, by water; its origin is a curious and interesting problem. As has been already remarked, the deposits in question are by no means uniformly auriferous individually, nor are many of the beds auriferous at all. Many deposits, belonging to each of the above classes, have been found to be exceedingly rich in places, whilst others, and other parts of the same bed, are barren. It will be readily understood that where the edges of the beds are exposed at the surface, and a long period of quiet denudation has supervened, the outcrops will have become abnormally enriched by a process of geological concentration. But there is more than this to be noticed, as rich portions of the deposits appear to occur, in which no structural or other difference can be detected from any other part, rather in the nature of zones than pockets or ore shoots, and to bear some regular relation to the position of the bed and the proximity of intrusive rocks. It appears that adjacent to the more disturbed parts of the ground these zones of auriferous matter are more than usually marked, and where the beds stand vertical or with a high angle of dip they appear to go down somewhat in a perpendicular direction. There appears to be some analogy between these auriferous bands and those noticeable in the auriferous compact quartzites of the Barberton district.

Turning north from Johannesburg, and crossing the ridge of hills of the Witwatersrand, on the road to Pretoria, the geological formations of the district are passed in a descending scale—first the stratified quartzites and then the shales, schists, and flagstones, until the granite appears from under them at the Yokeskey Spruit. Near to the Six Mile Spruit the calcareous quartzite is again observable with some trap, and the quartzites come in again just before reaching Pretoria. In these cases the beds are not of great thickness, and but thinly overlie the granites which appear outcropping repeatedly in every watercourse or other depression; and these conditions extend over a wide area of country.

In the granitic rocks occur mineral deposits entirely different from those hitherto noticed, and which may be classed as follows:—

(*a*) Surface fissures in the granite, filled with quartz, which is often to some extent auriferous near the surface, but extends to no great depth.

(*b*) True fissure veins, usually faults in the granitic rocks not terminable in depth, and carrying, as far as has yet been ascertained, argentiferous copper and lead, with antimony and many other minerals, but little or no gold.

The first class are of little value as workable deposits, the yield of gold and extent of the deposit being both, as a rule, very limited. The second are a class of deposits the importance of which it is hardly possible to estimate until they have been worked upon to a far greater extent than at present, but their possibilities may be almost anything.

The minerals so far proved to exist in these veins will undoubtedly some day have to play their part in the reduction of auriferous pyrites, and the silver they contain will add considerably to the value of the *matt* produced.

There is a great probability that veins will be found in these granitic rocks over a large extent of country. So far those of the Albert, the Willows, and the Tranvaal silver mines are the only ones on which any work of importance has been undertaken.

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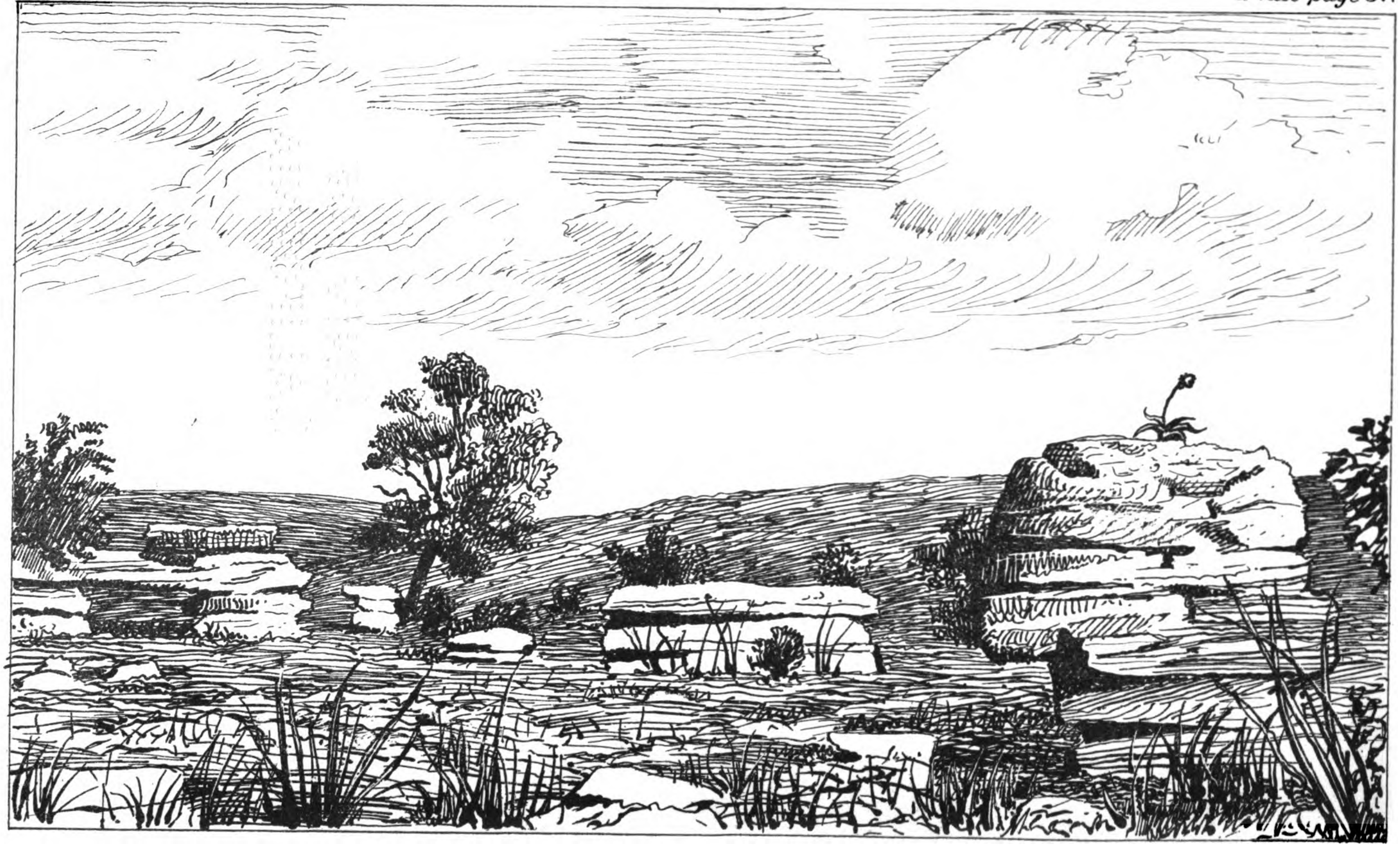
Plate IV.

to face page 31.



Stanford's Geogl. Estabt.

ERODED QUARTZITE AT BARRETTS BERLIN

THE DE KAAP VALLEY.

THE De Kaap district, of which the town of Barberton is the centre, occupies the extreme south-eastern portion of the Transvaal. On the south it is bounded by Swaziland and the district of New Scotland, on the east by the Portuguese territory of Delagoa Bay; on the north the Crocodile River separates it from the district of Lydenburg, and on the west the steep range of the Drakensberg Mountains borders the high central plateau and the district of Middelburg. On the southern boundary of the district flows the Komati River, on the northern the Crocodile, and between these run the Lomati, Queen's, and North and South Kaap rivers. All these streams run eastward, and eventually find their way into the sea at Delagoa Bay. What is known as the De Kaap Valley is a comparatively low-lying area of country, some thirty miles in diameter, and almost circular in form, on all sides surrounded by steep and rugged mountains; those on the western side, the Drakensberg, forming the edge of the great inland plateau which occupies the centre of Southern Africa.

The edge of this tableland is much broken, and forms a belt of very rugged and difficult country beyond which, towards the coast, lie flat plains and swamps extending to the sea. There are no forests, and trees of any considerable size are not plentiful; but on the mountain sides and in the ravines there grows a quantity of scrubby thorn-bush useful for fuel and other purposes, and after the rains, the whole country is covered with a luxuriant vegetation of tall grass and ferns, with many different species of wild flowers; indeed, the flora of this district would well repay a minute botanical study. The climate is healthy and cool during the dry season, from April to September; during the other months of the year the country is visited by very violent storms and heavy rains, and malaria, horse sickness, and other diseases of a like nature prevail in the low-lying districts towards the coast. In these districts also the ravages amongst cattle of the tsetse fly make settlement almost impossible.

In common with the rest of the Transvaal there are no railways, bridges, or made roads, and all transport is carried on by the ox-wagon. The terminus of the Delagoa Bay Railway is about one hundred miles from Barberton, and the intervening country by no means a difficult one for railway construction, consequently, the connection of this district with the sea by railway presents no grave difficulties. Such a connection is to the mining industry a matter of vital importance, as without it the inordinate expense of fuel, machinery, skilled labour, and all things necessary to the successful prosecution of mining or any other industry is prohibitory.

The geological features of this district are, at first sight, somewhat complex; but on investigation show themselves to be analogous to those of other parts of the country. We find as the base of the district a coarse-grained granite, passing in places into syenite and in others into pegmatite. The surface of these granitic rocks where exposed to atmospheric influence, is weathered and disintegrated to a very considerable depth, and the debris resulting from this disintegration and decomposition have been scattered and redeposited over a large area of country in all directions. Overlying the granitic rocks come a large series of mudstones, shales, and laminated clays, with thick-bedded compact quartzites, all interbedded and conformable to each other. These beds appear to have been sharply folded together, and have by the inequality of their denudation produced the rugged mountain range of the Makongwa, which lies to the south of Barberton, and forms the boundary between the Transvaal and Swaziland. In this series the quartzite beds are very persistent and recognisable, the upturned and exposed edges of some of them being traceable for many miles along the mountain range, and they appear to be very generally auriferous, occasionally to a considerable degree. In some parts they develop rich zones or bands of auriferous matter, as in the Sheba and other mines. In the clay beds the gold occurs in much smaller quantities than in the quartzites, there being usually little more than a trace.

On the western side of the De Kaap Valley occur the stratified sandstone quartzites and conglomerates which have already been noticed as forming so important a feature in the geology of the Witwatersrand. Here, as there, they immediately overlie the argillaceous strata, to which they are, as a rule, conformable, but in some cases not so. The beds are generally horizontal, or have only a very slight angle of dip, and their thickness varies very much locally. The conglomerates are almost invariably auriferous in some degree, but seldom highly so as at Johannesburg, although the conditions under which they occur are, with the exception of the greater amount of disturbance which they have been subjected to at the latter place, identical in both cases. This series of rocks is very characteristically developed at the Barrett's Berlin mine, where they are seen resting upon the lower series of the slaty rocks. Their weathering and erosion by effluent water and long continued atmospheric action, has left the remains of the upper beds carved into fantastic shapes, which produce a most picturesque effect, and has formed beneath them a labyrinth of underground caves and passages of considerable extent.

The upper sandstones of the coal formation are very poorly represented in the De Kaap district; some small beds of white and yellow sandstone, with some laminated yellow clays, which are found in a few places overlying the stratified quartzites, are probably the attenuated remains of these newer strata with which the older rocks have in earlier ages been covered, but the mass of these beds has long since been removed.

Thrusting their way through the granitic and the stratified rocks alike, we find a vast inruption of trappean matter forming intrusive sheets and dykes, the latter having a general north and south direction. Across the low ground of the valley of the De Kaap these dykes can be observed forming long razor-backed ridges, supporting on their flanks masses of the granitic rocks, through which they have forced their way. Where these igneous rocks have intruded themselves amongst the stratified deposits, they have naturally produced a very considerable disturbance of the stratification and metamorphism of their lithological structure. Subsequent denudation and redeposition of the resulting debris have produced an altogether newer local seeris of stratification, which reformed rocks, though of no very great extent or geological importance, are in some degree interesting in their gold-bearing capacity.

In recapitulation it will be well to view the geological structure of the district as it now presents itself.

In the valley of the De Kaap rivers we see exposed the granitic rocks with their weathered surface of kaolin clay and granitic sand worn by effluent water into deep *dongas* or watercourses. Long sharp rocky ridges mark the course of intrusive trap dykes which stand out clear across the valley, and the surface of the whole is covered with boulders and drift-rocks derived from all the rock formations of the country.

The Makongwa Mountains to the south show the clay beds with their interbedded quartzites folded and upturned into a vertical position, whilst on the west the lower parts of the steep escarpment of the Drakensberg presents the same series of rocks more nearly in their normal position and capped by the stratified quartzites and conglomerates. To the east, in the Jamestown district, the attenuated and upturned remains of the slaty rocks are covered deeply with beds formed of redeposited drift matter, whilst to the north the granites lie exposed as in the De Kaap Valley to the Crocodile River, and far beyond it through the wide belt of low country to the Murchison Hills.

The distribution of auriferous and other mineralised matter in the rocks of this district appears to occur under the following five conditions:—

1. In the interbedded compact quartzites and their accompanying clay rocks.
2. Surface fissures in the rocks of every formation.
3. The stratified conglomerates.
4. Isolated local bedded deposits formed on or near the present surface.
5. Recent alluvial deposits.

Up to the present time no deposit has been met with in this district of the nature of a true fissure vein, such as would traverse the granitic and stratified rocks alike regardless of bedding, strike, or dip; nor do the conditions of these rocks appear favourable for the occurrence of such deposits.

The interbedded quartzites and clay rocks are particularly well defined, the upturned edges of the former standing out distinctly in bold ridges many miles in length. These show their derivation from sandstone in a very marked manner, passing upwards into that rock by the most insensible gradations, and it is in these beds that the valuable auriferous deposits of the Sheba and other mines have been developed. This development of gold in stratified quartzite is a matter which deserves serious attention. The structure or lithological character of the richer gold-bearing portions of the beds in no manner differs from that of the surrounding poorer portions, except, perhaps, in an increase of the amount of talc, which is however present to some extent throughout the entire bed. The more auriferous portions appear to form zones or ore shoots in the plane of the bedding, and generally at right angles, or nearly so, to the line of strike.

The clay beds intercalated with the quartzites carry throughout their mass very little gold, though in some instances their surfaces or exposed edges have been enriched by geological concentration to a very considerable extent. At their contact with the quartzites they in some cases also become more auriferous, and also in these deposits the association of gold with talc is noticeable.

Interbedded with the quartzites and clays of the Makongwa Range there occurs a persistent bed of black cherty quartz, which also, in places, becomes rich in gold; and again a well-defined deposit of white and grey quartz, with silicates of iron and much pyrites, also, in places, traces of carbonate of copper, galena, and other minerals. These two beds are in intimate relation to each other, and may possibly be found on further investigation to be fissures in the bedding planes of the earlier rocks, filled by the subsequent deposition of their mineral contents, consequent upon the folded position of the strata of the Makongwa Range. We find the beds recurring as their line of strike is crossed from north to south.

In the Jamestown district they have a general strike of about north-west, but the disturbance has been too great to allow their individual recognition, excepting only in a very few cases.

In discussing the deposits of class No. 2, the surface fissures, a question of some mineralogical interest presents itself, namely, what influence, if any, have the trap inruptions had in the production of auriferous deposits? Their mechanical influence is apparent, as they have, by dislocating the strata, produced a number of surface fissures, irregular in every characteristic, which have become filled with quartzose and other matter carrying gold. A number of these deposits appear to have been formed wherever the intrusive rock has met with one of the compact quartzite beds, and many of these are exceedingly rich in gold, especially near to the surface. Naturally these fissures take all manner of directions in their strike, usually in the bedding planes of the stratified rocks, but sometimes crossing them; in no case do they extend laterally or in depth for any great distance. The filling of these fissures is usually a subcrystalline quartz, white, grey, or black in colour, sometimes much brecciated, and enclosing fragments of local rocks, and the gold appears rather to be developed in the matrix than carried in the derived rock fragments. This class of deposit occurs very frequently in the eastern portions of the district, and also on the Moodie's concession, to the south-west of Barberton, where some of them are of large size and consist of a large mass of sandy material, in which ramify in all directions small veins of quartz. In the same neighbourhood, also, the schistose beds are repeatedly intercalated with deposits of quartz, varying from a few inches to several feet in thickness, following the bedding planes of the strata, which are often locally very highly auriferous.

The small isolated bedded deposits of class No. 3 are formed of redeposited material, and occur very frequently in the Jamestown district. They are in no case of any great extent, and appear to have been deposited by currents of water in sheltered places, protected by the upheaval of some hard and durable bed, and then covered by more recent deposits. These are, as a rule, highly ferruginous, and some of them very rich in gold; they are associated generally with highly talcose clays and mudstones.

The conglomerates of class No. 4 form a totally different group of deposits to any of the above, and belong to an entirely different geological horizon. They are identical in all their characteristics with those of the Witwatersrand, and are, as there, associated with the sandstone quartzites overlying the strata of slaty rocks. In the district now under consideration, these beds are but poorly represented, occurring only at Barrett's Berlin and at the Kantoor, and in a few detached insignificant remains on the hills to the south and south-east of Barberton.

The auriferous alluvial deposits of class No. 5

are, in regard to the gold-mining industry, of the highest importance, though, unfortunately, so far their discovery has been very limited, and at the few points at which they have been worked the scarcity of water has prevented any very profitable results. In the eastern parts of the district, patches of alluvium carrying gold have been found along the banks of the De Kaap and Queen's rivers. On the hills of Moodie's concession, also, some such deposits have been worked at a high elevation, but though fairly rich, were not found to be of any great extent. The largest and most promising alluvial deposits which have yet been discovered in this district are those in the neighbourhood of the Kantoor and Barrett's Berlin, situated on the western side of the De Kaap Valley. The deposits are composed mainly of the results of the decomposition of trappean rocks, with quartzose, gravels, sands, and clays, all of them highly ferruginous, and they are found resting upon the sandstone quartzites, which themselves overlie the older strata of argillaceous rocks. The gold obtained from these deposits is generally very coarse, and nuggets of very considerable size and value are occasionally met with; one found at Barrett's Berlin, in 1888, weighed between sixty and seventy ounces, and one found during the same year at the Waterfall diggings over one hundred ounces. In almost all cases the gold shows signs of crystallisation, and the forms are often in a very perfect condition. Ordinary water-worn nuggets are not frequent in any of these diggings, showing that the gold, in its present form, has not travelled any considerable distance from the place of its origin. As a rule these beds of auriferous alluvium appear to lie along the sides of the trap dykes.

The question as to the possible occurrence of alluvial gold in, or with, the decomposed granites of the valley of the De Kaap rivers, is one which has naturally excited considerable interest in the neighbourhood; hitherto search in these rocks has not been rewarded with success, and there is no reason to anticipate that any deposits of value will be found there.

Small quartz veins threading the granitic debris carry traces of gold in some cases, but there is every indication that at one time a great rush of water has completely cleared out this valley, and carried away eastward to the Indian Sea whatever deposits once overlaid it.

That auriferous deposits of considerable value exist in the De Kaap district there cannot be the slightest doubt, but the mining industry is crippled from several causes. At present the very great expense of working is one very serious drawback, and the only remedy for this is the construction of railway communication. Whilst the mills have to be erected on water-power at long distances from the mines, involving expensive transport and the repeated handling of rock, none but the richest ore can be worked to profit, and water-power is not abundant or constant in most parts of the district. Wood for fuel is scarce and expensive, and daily becoming more so as the bush is cut and used. There is coal of good quality in abundance at no very great distance, which could be brought by railway cheaply to the mines; or from Delagoa Bay coal from Australia or Europe could be imported at reasonable cost. Cheap and regular carriage of material is an absolute necessity to these fields. Until the mills can be worked on the mines and the ore brought to them direct from the stopes without rehandling or the use of any great length of tramway, the majority of the mines of the district must remain unworked as soon as the richer and more accessible parts of the deposit have been picked out.

ZOUTPANSBERG.

Leaving Pretoria for the north we pass the Wonderboom Poort, a pass in a ridge of hills about six miles north of the town, so named from the presence of the remains of a gigantic wild fig-tree a short distance beyond it. Through the poort the Aapies river finds its way to the northward, and on either side, in the escarpment worn by its current, the quartzite beds are seen dipping north at an angle of about thirty degrees. To the south of the poort is an outcrop of trap rock to which the quartzites probably owe their elevation, and the granitic rocks are visible in the bed of the stream on both sides.

About five miles north of Wonderboom Poort occurs another small range of quartzite hills, also thrown up by an inruption of trap, after passing which we enter upon the great plain known as the Springbok Flat. This plain extends northward for a distance of nearly eighty miles to the hills of the Waterberg range. Its surface is covered with deposits of sand and peat, which overlie the granites in no very great thickness, and in places quantities of quartz pebbles have accumulated, amongst which some good specimens of agates, onyx, and jasper are occasionally to be met with. Excepting only the Pineaars and Aapies rivers, this plain is, in the dry season, almost entirely destitute of surface water, but as the surface deposits cannot be of any great depth, and a plentiful supply most probably exists on the granitic rocks below, this disadvantage might soon be obviated by sinking wells or boring. The soil is admirably adapted for agriculture and only requires irrigation to become fruitful.

About twenty-five miles north of Pretoria there is a rather peculiar salt-pan. A large circular cavity bearing in form a great resemblance to a volcanic crater has been formed in the granite, and the saline deposit occupies the bottom of this basin. The granite is of a very coarse porphyritic variety, with large distinct crystals of pink felspar and glassy quartz, and with rather few but large crystals of hornblende, in places also a quantity of white and brown mica is present. Round the edges of the basin the granite rises in a wall to a height of 100 feet above the surface of the surrounding plain, whilst the surface of the saline deposit in the centre is 125 feet below that level. The surface of the salt deposit is perfectly level, and is covered with a stratum of mud several inches in thickness, which in the wet season is covered with water which becomes saturated with saline matter from the deposit below, and on evaporation deposits a layer of salt on the surface of the mud. The analysis of samples of the saline matter from various parts of this deposit are as follows:—

Sample No. 1.

Chloride of sodium	95·6
Impurities and water	4·4
	100·0

Sample No. 2.

Carbonate of soda	70·17
Chloride of sodium	9·33
Impurities	1·60
Water	18·90
	100·00

Sample No. 3.

Carbonate of soda	34·15
Chloride of sodium	5·77
Water	24·20
Impurities	35·90
	100·00

The deposit has on the surface an area of about 400,000 square yards, and its depth is probably very considerable, but has not yet been ascertained. It is a geological problem first to account for the granitic cone, and secondly for the presence of the saline deposit in its centre, which must certainly be referred to a period very recent in comparison with that of the formation of any of the rocks of the neighbourhood.

About seventy miles north of Pretoria, on the road to Nylstroom, the warm baths are reached, where there is a small hotel and coach station, whilst the encampment of Boers, with their tents and waggons, who come to benefit by bathing in the hot water, forms a wild and picturesque scene. These natural hot springs well out from the ground, amidst a dense mass of peat and reeds, into a roughly made basin or pond, from which the water is conducted by pipes into baths for the use of those who choose to pay a small sum; but the Boers are generally quite satisfied to make for themselves a small hole in the ground, which, covered sometimes with a tent or a rude shed of reeds, forms the family bath, in which they sit in the hot water and mud for many hours of the day. At times there are several hundreds of these people encamped at the place.

The water is very pure, soft, and limpid, leaving on the skin after bathing a soft, silky feeling. The temperature of the water on issuing from the ground appears to vary from one to two hundred degrees Fahrenheit; but, as cold and hot springs are allowed to run together into the same place, it is somewhat difficult to ascertain.

An analysis of samples of the water published by Dr. Hann, of Cape Town, is as follows:—

One gallon of this water contains in solution—

Carbonate of soda	**16·84**	**grains.**
Common salt	**9·168**	**„**
Carbonate of lithium	**·12**	**„**
Carbonate of lime	**1·82**	**„**
Carbonate of iron	**·29**	**„**
Sulphate of magnesia	**·36**	**„**
Silica	**2·45**	**„**

The soil through which the hot water comes to the surface is a sandy peat, but the granitic rocks are probably at no great distance below.

The hills to the north are of white and red sandstone, somewhat analogous to that which overlies the coal beds in the more southern districts; but hitherto no indications of coal have been discovered in this neighbourhood.

Leaving the warm baths and proceeding in a northerly direction, a ridge of sandstone is crossed, the disintegration of which rock forms loose sand and renders the road heavy and difficult, and we enter upon a wide stretch of peaty marsh which forms the source of the Nylstroom, a river which, when the early pioneer Boers reached and found it flowing to the northward, they mistook for the sources of the Egyptian Nile.

At this point is a peculiar wedge-shaped hill called Krantzkop, forming an isolated outlier of the quartzite and conglomerate beds, which are very distinctly recognisable in horizontal strata, and show by their isolated position, as also by the immense masses of debris by which the country is covered, to what an extensive denudation the present land surface has been subjected. To the east lies the little settlement of Nylstroom, from which a track passes away to the north-west over the Waterberg and Zandberg hills, and down the valley of the Palala river into Bechuanaland and Matabeleland. Along this road the quartzites and conglomerates, and also the overlying sandstone beds, are well represented; but the country at present is but little known.

Passing up the left bank of the Nylstroom river the road skirts the base of a range of sandstone and quartzite hills, with occasional exposures of the lower series of stratified rocks, granites, and trap, until the river is crossed at Mooradrift, and a short distance further to the north-west the little township of Potgieter's Rest is reached, and Makapan's Poort about twelve miles further on. The hills on either side of this valley are of the clay shale and quartzite formations, with thick masses of conglomerates in places, granite and trap rocks occurring frequently in the water-courses and river-beds. The valley is fertile and well watered, and trees of moderate size are plentiful.

From the top of a high hill south of the road named Uitkyk Beacon, a magnificent view of the country for many miles is obtainable, the hills of the Magaliesberg, near Pretoria, distant more than 130 miles, being distinctly visible across the intervening flat country.

The Makapan caves, in which large numbers of natives were massacred in one of the early wars, and in which quantities of skulls and bones, with numerous relics of the victims, are still to be seen, are large water-worn cavities in the stratification of the quartzites, formed by the removal of portions of the softer beds. There are a number of caves of this class in the neighbourhood.

To the westward also of the Nylstroom river, in and about an exposure of granitic rocks, occur several other springs of warm water of a like nature to the one which has already been described.

East of Makapan's Poort, about twenty miles distant, lies the district of Ersteling, where auriferous deposits have been worked for some years. These deposits are surface fissures in the bedding planes of the slaty rocks and others, of a similar nature to those described in the De Kaap district, occurring usually in close proximity to the granitic and intrusive trappean rocks.

Further north, also, between the towns of Smitsdorp and Pietersburg, there is another belt of these same rocks lying east and west, and in this, at Mount Maré, Palmeitfontein, and other places, deposits of a similar nature are being worked for gold.

The country in this neighbourhood consists of ranges of quartzite hills, with exposures of the lower slaty rocks, all much dislocated by intrusions of trap; the intervening plains being covered with sandy peat and loam. The long denudation of the strata has resulted in the formation of very extensive surface deposits. To the west of Pietersburg, on the road to Hannertsburg, occurs an extensive exposure of the granitic rocks with some very peculiar *koppies*, or little hills, each formed of a solid mass of granite, which stand out bare and round on the plain like gigantic heaps.

On nearing Hannertsburg, the steep and rugged country of the Drakensberg is entered, and the road becomes rough and difficult. All the formations of the country are represented, from the granitic rocks upwards in their regular order as mountain or valley is crossed. A short distance to the south of Hannertsburg the quartzite and conglomerate beds attain a very considerable development, and the latter have been found auriferous, but not hitherto to any payable extent. The mountains of the Drakensberg are almost everywhere capped with these strata, which usually lie horizontal or with no great angle of dip, and whose bold escarpments form a striking feature in the landscape.

From the mountains in the neighbourhood of Hannertsburg and Woodbush, some extensive views over the low country are obtainable; from the foothills of the Drakensberg, the flat country is seen stretching away eastward to the horizon like a sea of bush, only broken here and there by the protrusion of a few little rocky koppies, which stand out like islands, whilst on the far eastern horizon the Lebomba Hills in the Portuguese territory border the swamps on the coast of the Indian Ocean.

The roads over the Drakensberg into the low country are exceedingly steep and difficult, as no trouble is taken to make them up or keep them in repair; they are, in fact, mere hunter's tracks. The road by Buffles is by far the most practicable, though that known as Woodbush Hill is a nearer route to the Murchison range by many miles. There is also a route *viâ* Lydenburg and the Origstad Valley, the worst part of which is between the Origstad and the Olifants rivers where there are two exceedingly steep hills, but these once passed there are no further very great difficulties. None of the rivers are dangerous or difficult to cross in the dry season, but when swollen by heavy rains, even small streams, which at other times are dry, become impassable, and the larger rivers, such as the Olifants and the Letaba, become raging torrents of great width and volume.

In the wet months of the year, travelling in the low country is both difficult and dangerous, as in addition to the heat and swollen rivers malaria fever is very prevalent, and at all times of the year horse-sickness and other diseases, with the deadly tsetse fly, make it almost impossible to keep horses or oxen. The fly is less deadly to donkeys, which in the more eastern districts are almost the only animals in use, but in many cases these also succumb. The fly is a harmless looking little creature, not much larger than a housefly, but with a longer body and pointed wings; it appears to frequent the neighbourhood of bare rock surfaces such as the granites and trap, which retain the heat of the sun well during the night, consequently some regions are infested with them to such an extent that no horses or oxen can even pass through them and live, whilst in other adjacent parts the fly is entirely absent.

The former are called *Fly-zones*, and some of them are known well, and consequently always avoided by travellers. It is a current saying that "the fly follows the wild game," but this appears to be an error, and rather the reverse to be the case. The fact appears to be that as hunters will not follow the game into the fly-zones for fear of losing their horses and oxen, the wild animals learn to regard these places as safe asylums, and consequently congregate there; thus the game and the fly are found together.

Numbers of wild animals inhabit the bush of this low country. Elephant, giraffe, buffalo, zebra, and numerous species of buck and wild cattle are plentiful, as also are lions, leopards, panthers, and others, whilst in the rivers are hippopotamus, rhinoceros, and alligators.

The whole surface of the country is covered with thick but not very high thorn bushes and very long rank grass, which grows in places to a height over ten or twelve feet. In such a country the examination of the rocks is a matter of time and difficulty.

The whole of the low country generally appears to be granitic. These rocks are greatly decomposed at the surface, and are covered with masses of drift of all kinds, sometimes to a very considerable depth. The granitic rocks vary much in texture, composition, and in other characteristics within a very limited area. In places we find a fine-grained true granite, generally grey in colour, at others the mica is replaced by hornblende, when often the crystals of felspar are pink and very well defined. In other places the granites pass into gneiss, and again into felsite or pegmatite, the latter rock being usually purely white in colour, and with the quartz crystals very distinctly developed; it sometimes carries a few very large flakes of a silvery white mica. These rocks are traversed in all directions by dykes and intrusions of trap rock of many different varieties, which have successively forced their way through them. Where these rocks have come through in large masses they have faulted and disrupted the granites very extensively, but have left large areas of them intact in their neighbourhood; but where they have come through in comparatively narrow dykes and veins they thread the granites with a perfect network in all directions. This latter condition appears to occur more frequently close under the Drakensberg, and the former at a greater distance to the eastward.

In the bed of a watercourse called the Makutso, on the road between the Olifants and Silati rivers, occurs a very distinct and large dyke of diorite, with branches ramifying into the granite in all directions; the whole is very compact and tight, and it is easier to break the rock anywhere than at the point of contact.

Overlying the granites are the attenuated remains of the shales and mudstones, as a rule only in small and detached patches, but in some cases forming hills of no great altitude, such as the Sutherland, Murchison, and Paloboro ranges. These strata invariably show signs of having undergone great disturbance by the intrusion of the igneous rocks by which they are repeatedly cut. In this disturbed mass the remains of the compact quartzite beds are recognisable in boulders and fragments; and surface fissures, such as we have seen in the Barberton district, are of frequent occurrence.

As might be expected from the nature of the ground, a great development of talcose minerals has supervened, and, in the quartz, crystals of tourmaline, hornblende, and pyroxene, with some fine dendrites of manganese oxide, are common. In some places the blocks and boulders of quartzite have developed a considerable quantity of gold, which, however, does not enter into the composition of the mass as in the case of an ordinary gold-bearing mineralised quartz, but appears generally in the fissures of the rock, in nuggety impregnations; thus, as the whole of the gold is usually visible to the eye, the appearance of the rock frequently gives to the observer an idea of excessive richness which is not borne out on assay. The gold in all cases is crystalline in structure, and occasionally most beautiful cabinet specimens are to be met with. The small quartz veins intercalated with the clays are also at times found to be auriferous, especially at and near the surface, as also are the surface deposits of bog iron ore and ferruginous sands.

Some of the river beds have a promising appearance for alluvial gold, but hitherto the country has had so little examination that it is impossible to say if any payable alluvial goldfields exist or not.

It is probable that where the granite is faulted, as is the case along some of the before-mentioned ranges of hills and other places, a development of metalliferous mineral may have occurred in the fissures of the faults; but these appear more likely to develop argentiferous copper, galena, antimony, and minerals of that class, than gold.

In the neighbourhood of the Murchison Hills, as also at Paloboro, signs of the existence of these fissure veins are not wanting, but immediately under the escarpment of the Drakensberg the condition of the granitic rocks is not so favourable for their occurrence.

The ranges of hills which stretch out from the base of the Drakensberg into the low country are,

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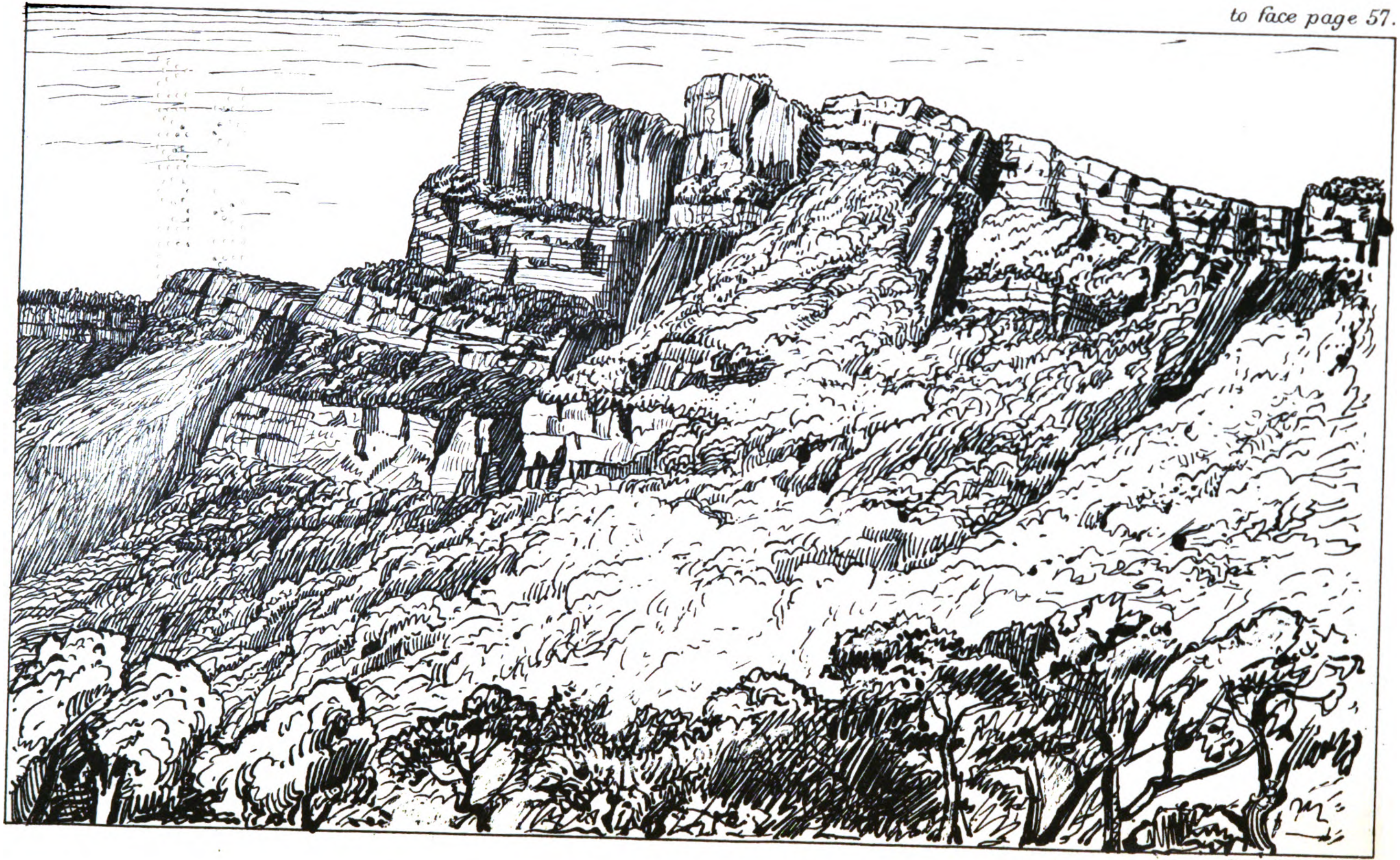
Plate V.

to face page 57.



Stanford's Geog^l Estab^t.

QUARTZITE CLIFFS OF THE DRAKENSBERG.

as far as has yet been observed, all composed of the quartzites, clay shales, and mudstones, under varied conditions as induced by the varied nature of their disturbance and subsequent denudation, and in the Makongwa Range of the De Kaap district, and the Paloboro, Murchison, and Sutherland hills, of Zoutpansberg, the general characteristics are much the same.

On the Murchison Range, from the township of Agatha east for some fifty miles, and also in other parts of the country between the rivers, there is a great scarcity of surface water in the rainless months, which would prohibit the use of steam machinery, and thus constitute an almost insuperable obstacle in the way of economical mining work; but it is possible that by sinking wells or boring in carefully selected places a supply could be obtained.

The construction of a railway from Delagoa Bay into the low country of Zoutpansberg would be a matter of no very great expense, but some engineering skill will be required to carry it in safety over the swamps and sands and to bridge the rivers. The port of Delagoa Bay is the natural outlet for this country, instead of the steep and difficult tracks over the Drakensberg. The distance from the Murchison Range to the present terminus of the railway at the Portuguese frontier is only about 210 miles. Nothing but railway communication with the coast can ever adequately open up this country; and nothing but opening it up, with drainage and cultivation, will render it healthy and a suitable habitation for Europeans, or one in which mineral deposits, unless of the most exceptional richness, can be worked at payable cost.

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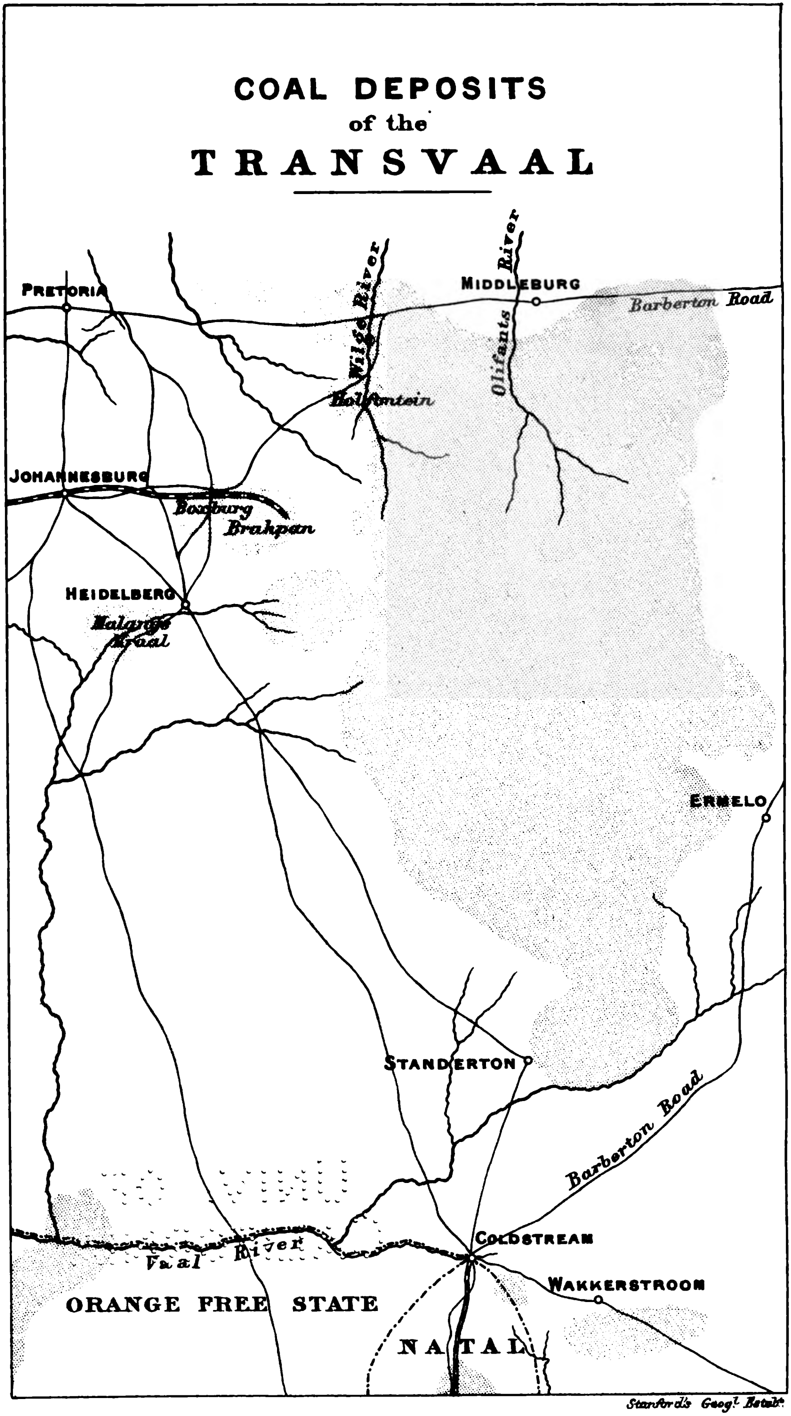

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COAL DEPOSITS.

In the Transvaal there are no large rivers, and such streams as there are flow for very long distances with very little fall through the comparatively flat country of the central districts; consequently, when not swollen by heavy rains, they creep sluggishly on between steep muddy banks covered with reeds and rank vegetation, and in the dry season carry a very limited volume of water. Under these conditions there are but few places at which the water can be made available as a motive power for machinery of any kind, and the use of steam becomes absolutely necessary. Coal thus becomes of the first importance to every industry, and fortunately nature has provided in this country a bountiful supply of a very useful quality for almost every purpose.

The coal formation consists, as we have already noticed in treating of the classification of the rocks of the country, of a series of beds of silicious sandstone intercalated with clays, shales, and local beds of coal. These beds form a series varying from 20 to 200 feet in thickness, and rest generally unconformably on the series of quartzites and conglomerates described fully in the chapter on the Witwatersrand. Between the two there often occurs a bed of brecciated quartzite, with many fragmentary rocks of very varying thickness.

The coal beds are not continuous one with the other, nor is any individual bed of very great extent, but in some districts they are very frequent, so much so, that in several places the coal may be said to be practically continuous over a very considerable area. The beds are of lenticular form, usually horizontal, and in slightly different horizons. So far not more than one workable bed has been found at any one point, but in several cases the coal is overlaid by one or more strata of semi-carbonaceous matter. The seams of coal vary in thickness from a few inches up to thirty feet or more, and they are usually underlaid by a bed of shale.

A bed of fairly pure silicious clay is found in many cases, sometimes above and sometimes below the coal seam, which makes a fairly useful fireclay, but in no case has this been noticed to occur in the same relation to the coal as the true fireclay of European coal measures. The quality of the coal varies very much, not only in adjacent beds, but in the same seam, being frequently intercalated by partings of shale; some parts also of the seam are dull and hard, whilst others have a bright jetty appearance and are very friable. The fracture is generally conchoidal. Pyrites occurs frequently at times, disseminated in the more shaly parts of the seam, but more often in well-defined patches or bands. Under the microscope the thin laminæ of coal are seen to be intercalated by a slight coating of silicious matter. An analysis of a fair sample of coal from the neighbourhood of Middelburg gives—

Carbon	72·80
Hydrogen	5·75
Nitrogen	1·90
Sulphur	3·80
Moisture	1·60
Ash	14·75

A sample from a colliery some miles nearer to Johannesburg gives:—

Carbon	65·20
Hydrogen	3·00
Nitrogen	2·30
Sulphur	2·15
Moisture	1·35
Ash	23·30

The coal differs much in its combustion; some specimens are difficult to ignite, and require a strong draught, whilst others burn with violence and much flame and smoke; in both cases a copious earthy ash, sometimes red in colour, remains. In no case, as yet, has any of the coal of this country been found to yield a hard coke, such as would be suitable for metallurgical purposes; that obtained being soft, porous, and friable, resembling the ordinary gas coke. An analysis of a sample of coke made from some of the Middelburg coal gives:—

Carbon	74·50
Hydrogen	·50
Nitrogen	·30
Oxygen	·10
Sulphur	4·20
Moisture	·40
Ash	20·00

This coal could be used for the reduction, or matting, of ores in reverberatory furnaces, or under any circumstances where the sulphur and impurities would not be of much consequence, but it would not be suitable for other metallurgical purposes. It also deteriorates very much from exposure, and should never be stacked in large quantities, on account of the danger of spontaneous ignition from the heat generated by the decomposition of the iron pyrites.

The sandstones and clays which belong to the coal formation of the country are traceable over a very large area, as will be noticed on reference to the accompanying geological map. They occupy a large tract of country known as the Highveldt, extending from Middelburg on the north, to Standerton on the south, and Ermelo and Lake Chrissie on the east. Around the edge of this main mass of the beds occur several outliers, as at Boksburg, Skietpoort, Malang's Kraal, in the Witwatersrand district, and also near Wakkerstroom, Utrecht, and Luneburg to the south. On the extreme edge of the Drakensberg, overlooking Swaziland, in the district known as New Scotland, patches of the coal formation are also observable. On the Vaal river, at its junction with the Klip river, also occurs a considerable patch of the coal measures, on which lie the valuable collieries belonging to Messrs. Lewis and Marks.

It must not, however, be supposed that, wherever the sandstones of this series are found, necessarily the coal is there also. On the Pineaars river, north of Pretoria, occurs a patch of a similar yellow silicious sandstone, and the Waterberg Hills are also composed of sandstones and clays of a like lithological character to those of the coal measures, but in neither of these places has any coal as yet been found.

The geological age of these local coal deposits is a matter of scientific interest, but one of no commercial importance. The coal is a good useful fuel, and it is the only available fuel in the country; whether it belong to the Carboniferous, Jurassic, or Tertiary period of geology, can make no difference to it. Fossils are very rare, and those hitherto found are imperfect and obscure, thus there is little light to throw on the question. Those which have come under the notice of the author are the following:—

Lepidodendron.—Three casts in silicious sandstone, all imperfectly defined.

Pecopteris (fern).—Two impressions in the coal, one good, one doubtful.

Neuropteris (fern).—Five impressions in the coal, all somewhat doubtful.

Cycadean fruit.—One doubtful specimen.

This very meagre collection throws but little light upon the subject, and it is to be hoped that further search will be better rewarded. The finding of any remains of animal life has not yet been recorded.

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Plate VII. *to follow page 64.*

Section of Coal measures at
BRAKPAN COLLIERY

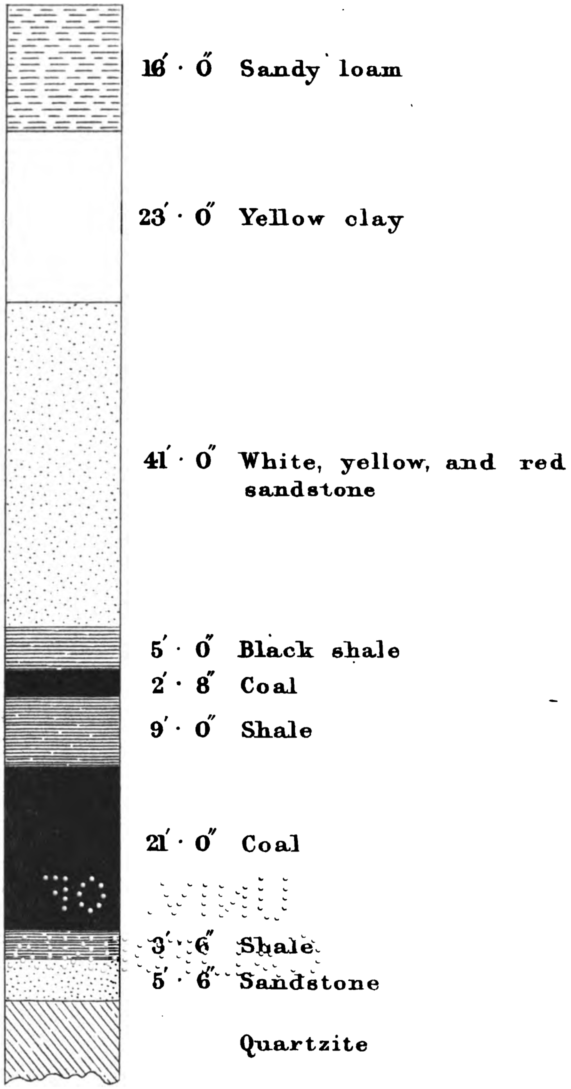

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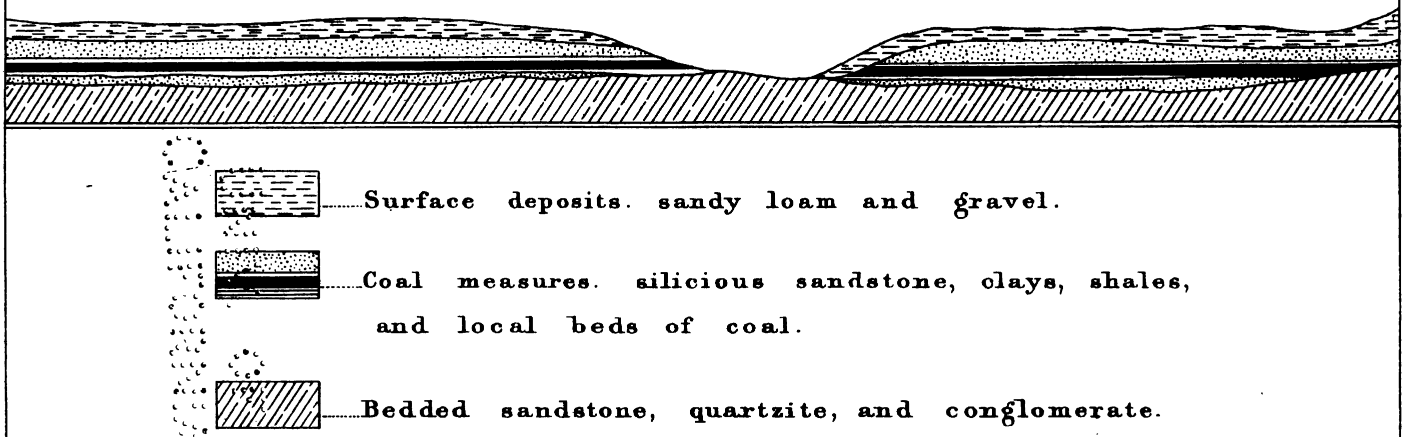
Plate VIII. *to face plate VII.*

Section of coal measures at **BRAKPAN COLLIERY**



Surface deposits. sandy loam and gravel.

Coal measures. silicious sandstone, clays, shales, and local beds of coal.

Bedded sandstone, quartzite, and conglomerate.

Stanford's Geog^l Estab^t

MINERAL PRODUCTS.

For the sake of more convenient reference, it will be useful to recapitulate under separate headings the various mineral products of value occurring in the Transvaal, with notice of the several localities in which they have hitherto been observed.

Gold.—In the interbedded conglomerates of the Witwatersrand and other parts; in the compact quartzites interbedded with the slaty rocks of the Makongwa range, and wherever those strata occur; in the quartz occurring in the bedding planes of the slaty rocks, and in surface fissures in the same formation; in surface deposits of ferruginous sandy matter; and as alluvial gold in recent beds of very varied character.

Silver.—In combination with copper and lead, with many accessory minerals, in fissure veins in the granitic rocks in the neighbourhoods of Pretoria, Malmani, Rustenburg, the Olifants river, north of Middleburg, and probably in the low country east of the Drakensberg. The ordinary silver ores, such as the chlorides and sulphides, or native silver, have not yet been met with in this country.

COPPER.—In fissure veins in the granites, as at the Albert mine and other places. This metal appears to be widely distributed in small quantities, but hitherto no considerable deposit of the pyrites has been met with. At the Albert mine the mineral is chiefly *bornite* and *grey copper*, with *galena* and *fahlerz*, all more or less argentiferous.

LEAD.—In the fissure veins in the granite as *galena*, resolving into *cerussite*, *pyromorphite*, and other such like minerals near the surface. These with *crocoisite* and *anglesite* are specially observable at the Transvaal silver-mines. In the Malmani and Rustenburg districts the native red oxide of lead, *minium*, is of frequent occurrence. In masses of white quartz filling surface fissures in the slaty rocks in the neighbourhood of Blaauwbank, on the road from Johannesburg to Rustenburg, impregnations of galena are frequent.

TIN.—*Cassiterite* is said to have been met with near to the Limpopo river, in the extreme north of the Transvaal, but no reliable information has yet come to hand.

ZINC.—Some small quantities of *blende* are occasionally met with in conjunction with galena in the fissure veins in the granitic rocks, but no *calamine* or *silicate of zinc* has yet been observed.

IRON.—This metal is very widely distributed in various forms, its oxide colouring almost all the rocks of the country, and entering more or less into the composition of every metalliferous deposit, but hitherto no workable quantity of any ore suitable for the production of commercial metallic iron has been observed. Bog iron ore, *limonite*, occurs frequently in beds and masses on the surface in all parts of the country, and especially round about the *pans* or water-holes on the Highveldt. Magnetic iron ore, *magnetite*, occurs in masses and surface veins in the granitoid rocks and in the more highly altered quartzites; and *iron pyrites*, sometimes highly auriferous, is of frequent occurrence in almost all the rocks of the country. Various forms of *hematite* are also abundant in small and widely distributed quantities.

MERCURY.—At a point in the low country, on the route to Delagoa Bay, about sixty miles east of Barberton, *cinnabar* has been discovered in small quantities in a coarse silicious sandstone with iron oxides and some talcose minerals. Deposits of the same ore have also been reported from the northern and western districts, but hitherto no reliable information has been received regarding them.

COBALT AND NICKEL occur in the form of *smaltine*, *cobalt bloom*, *nickeline*, and other varieties, associated with blende, galena, and carbonates of copper, in what appear to be fissure veins passing through the slaty rocks into the granite, at a point on the Olifants river about forty miles north of Middelburg. Traces of the same minerals have also been observed in the ore from the Transvaal silver-mine.

SALT occurs in beds exposed at the surface at the point described, about twenty-five miles north of Pretoria, and also in the extreme north of the Transvaal on the Ingalele river in the district of Zoutpansberg. The deposits yield a fairly pure *chloride of sodium*, with other salts.

MINERAL OIL.—Traces of bituminous matter have been met with in connection with peat and semi-carbonaceous beds in the coal formation of the Highveldt, also near Potchefstroom and in other parts, but nothing as yet showing any prospect of a valuable oil deposit.

LIME.—As yet no true limestone has been noticed in the Transvaal. A *calcareous quartzite* is of frequent occurrence which yields a serviceable lime on calcination, also a species of *dolomite* is occasionally met with in local beds and also in rounded nodules, in which a central core of some other substance, often a water-worn quartz pebble, is covered with a considerable thickness of concentric rings of dolomitic lime. Crystalline *calcite* also frequently occurs in deposits of no very great size, which have evidently been formed by the dissolving out and redeposition of the lime of the calcareous quartzite. The formation of stalactites in the caves at Wonderfontein and elsewhere is to be accounted for in a similar manner. In a country whose rocks are generally so highly quartzose in their nature as are those of the Transvaal, the occurrence of calcareous deposits of any considerable size can hardly be expected.

Building Stone.—The silicious sandstones which overlie the coal, form in most cases a stone of excellent quality for building purposes, as it is easily cut, and has usually no natural cleavage. It is generally very free from impurities, and on exposure to the atmosphere hardens to some extent on the surface. Some portions also of the granitic rocks form a very durable and beautiful material, but this rock is difficult to quarry and dress, and is consequently expensive.

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